Report on SF system studies 2

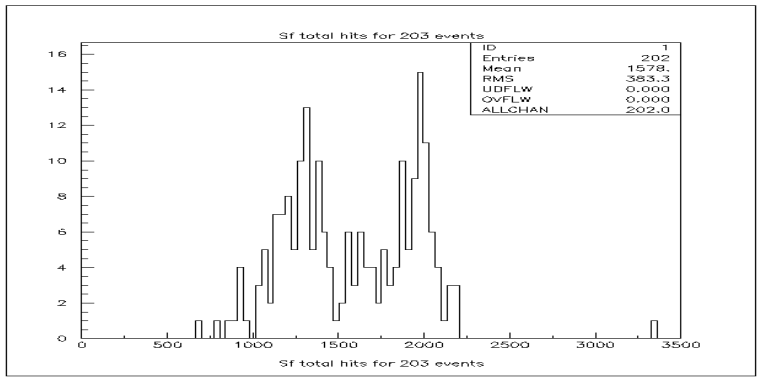
- Reviewing from previous presentation :
  - Aim : Compatibility between Data and MC in SF system
  - Methods under study :

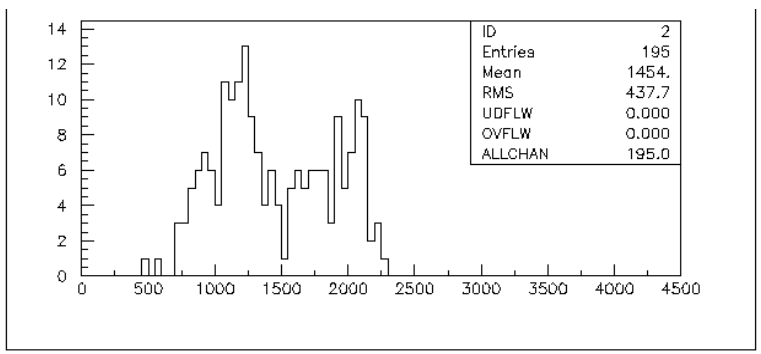
    (A)Improve pulse height (and hit) generation in MC data (SF decoder2) and add background in MC (hybrid MC files)

    (B)Subtract Background from data (pulse height cut)

- In this report we present studies on (B) and (A) w.r.t the different behaviors of the 2 decoders.

203 neutrino events & per 3 not muons





- On the top histogram you see the distributions of total number of SF hits for the 203 neutrino events and on the bottom the same distribution for per3 not muon events
- These two distributions are not essentially different so we can assume that doing the following analysis using per3 not muon events leads to reliable results
- The reason we have not used 203 events is that we haven't produced (till know) an MC file with per1 per2 per3 & per4 events in the same percentage .

SF1 and SF2 t1t3 event studies (Intro)

- For the following analysis we use t1t3 events that are muons passing throughout the spectrometer (~1000 events). We selected these events by requiring : i) Only one final track ii) That track to have hits in the SF system.

- DEFINITIONS:

  Type A Muon hits : The ones that were used in the muon track

  Type A Background hits : All the rest

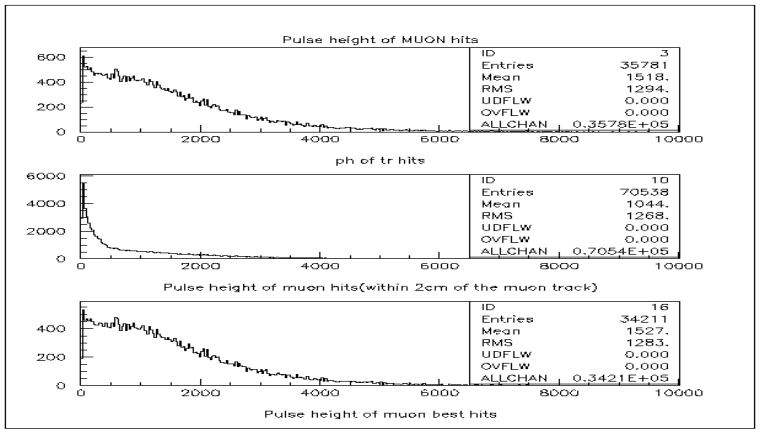
  Type B Muon hits : All the hits within 2 cm of the muon tracks (in all SF planes)

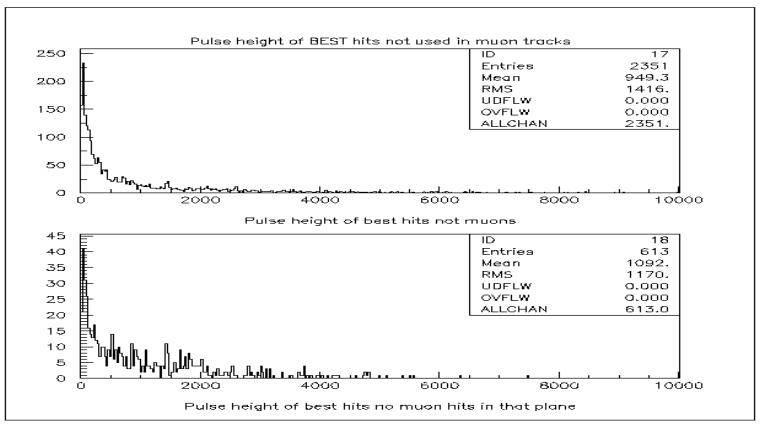
  Type B Background hits : All the rest (2 cm away of the muon track)

  Best hits : These are hits with the highest Pulse height within 6 mm (~ 12 fibers) of the muon track.

- Used SF1 decoder and SF2 decoder.

SF1 t1t3 event study - Pulse height of muon track hits



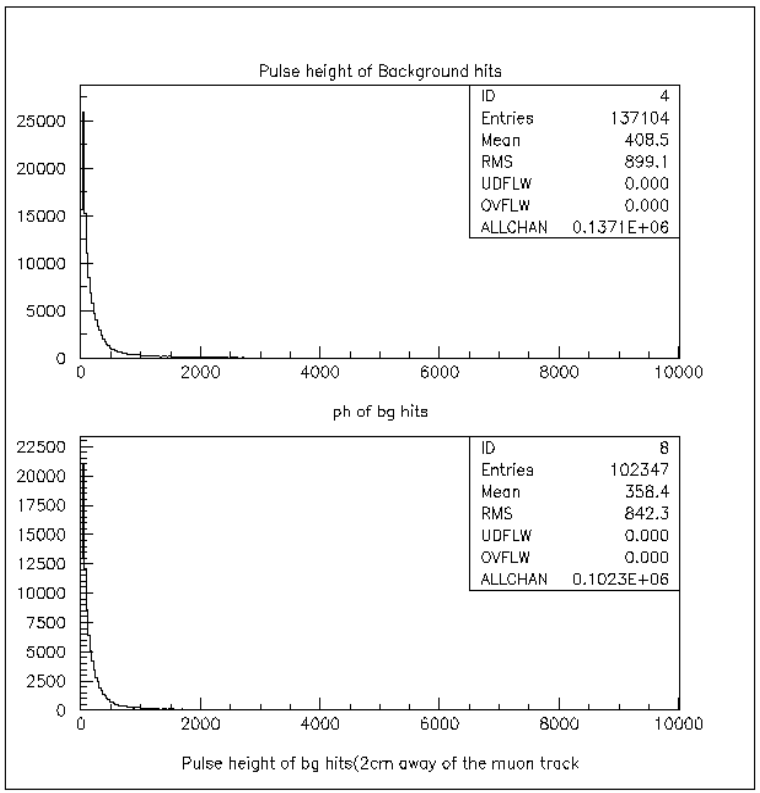


- In the first histogram we see the pulse height distribution of muon track hits (type A) (mean ~ 1518). In the second, the same distributions if we consider as muon track hits the ones within 2 cm of the muon track (type B) (mean 1044). In the third we see the same distribution but for muon track hits that were the **best hits** within 6 mm (mean ~1527).

- In the next 2 histograms we see the pulse height distributions of best hits (within 6mm) with muon hits (type A) in that plane (top) and without muon hits (type A) in that plane(bottom).

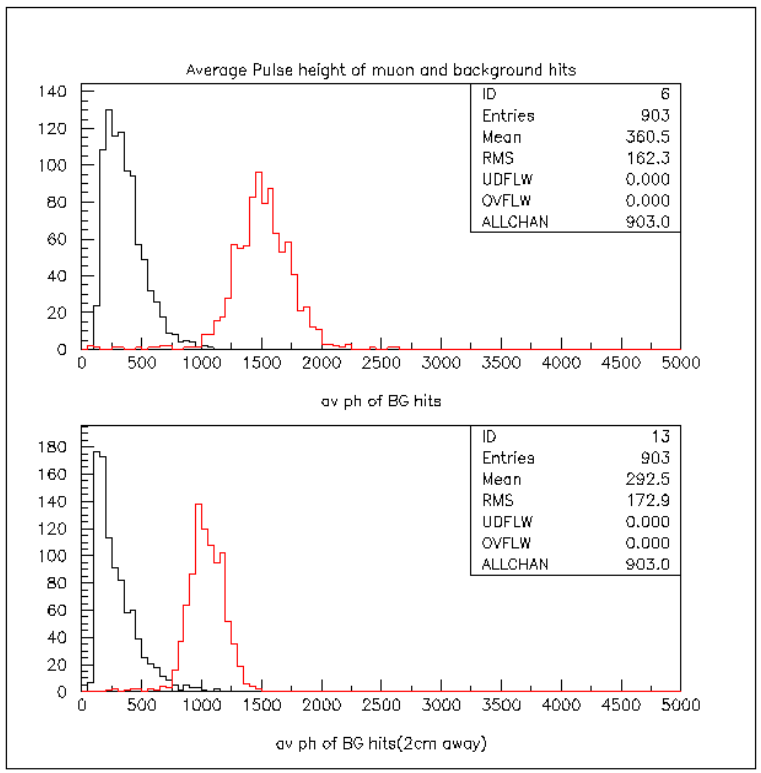
- We conclude that a) The tracking code most of the time includes the Best hits in a plane and b) The rest hits that are within 2 cm of the muon track are in their majority most probably background hits

SF1 t1t3 event study - Pulse height of Background hits



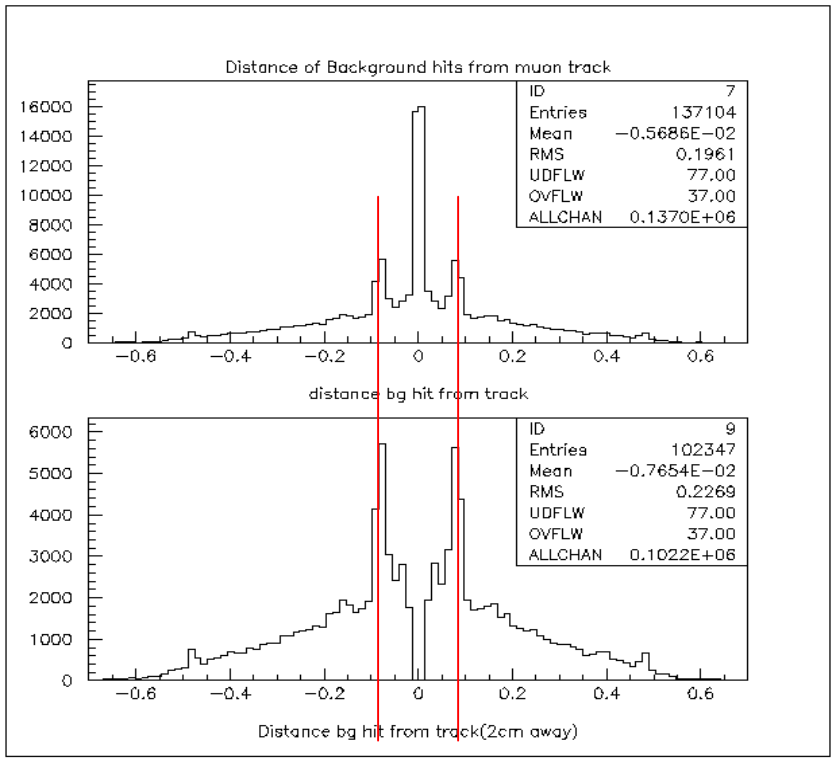
- On the top histogram we see the pulse height distribution of background hits (all the ones that do not belong to the muon track) mean ~ 408 (type A background)
- On the bottom histogram we see the pulse height distribution of background hits that are 2 cm away of the muon track. Mean ~ 360 (type B background)
- The slight difference is due to the fact that in the top distribution we are considering as background hits some that belong to the muon track.

SF1 t1t3 event study - Average pulse height of Background and Muon hits



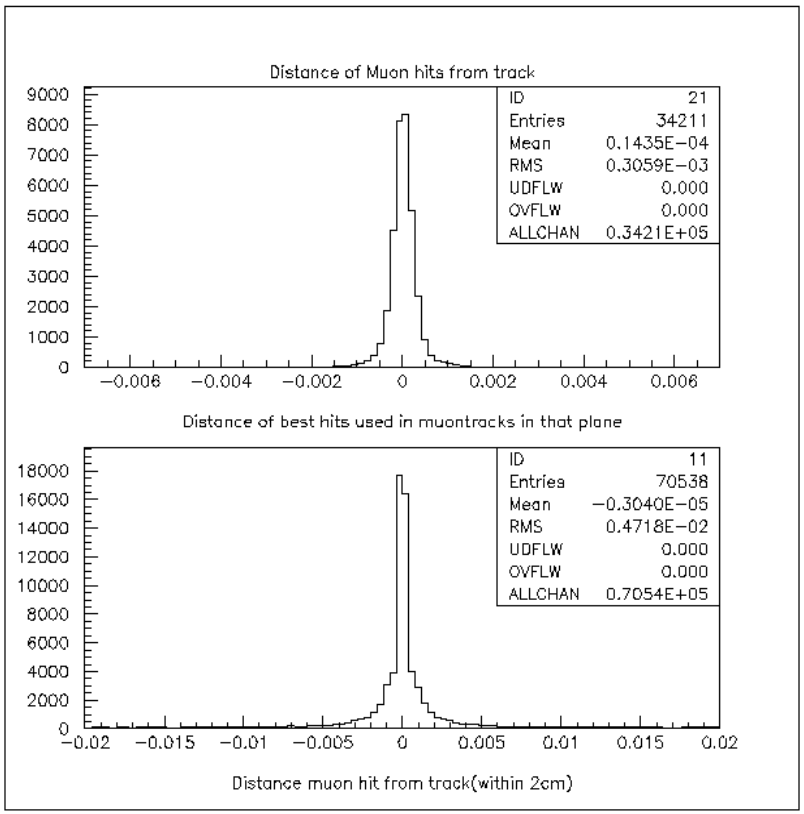
- In the top histogram we see the average pulse height distributions of muon and background hits.
- In the bottom histogram we see the average pulse height distributions of muon and background hits with the 2 cm cut.
- The mean values in the second are lowered but these 2 distributions are still not highly overlapping.

SF1 t1t3 event study - Distance of Background hits from muon tracks



- On the top histogram we see the distance distribution (in m) of background hits from the muon track (the peak on zero is due to large binsize).
- On the bottom histogram we see the distance distribution of background hits, 2 cm away of the muon track, from the muon track.
- What is unusual is the presence of the two peaks (red line) symmetric to the center for both these 2 distributions that correspond to a distance of ~ 8 cm (<=> 40 fibers)
- The same behavior is also observed in the corresponding distributions with SF2 decoder.

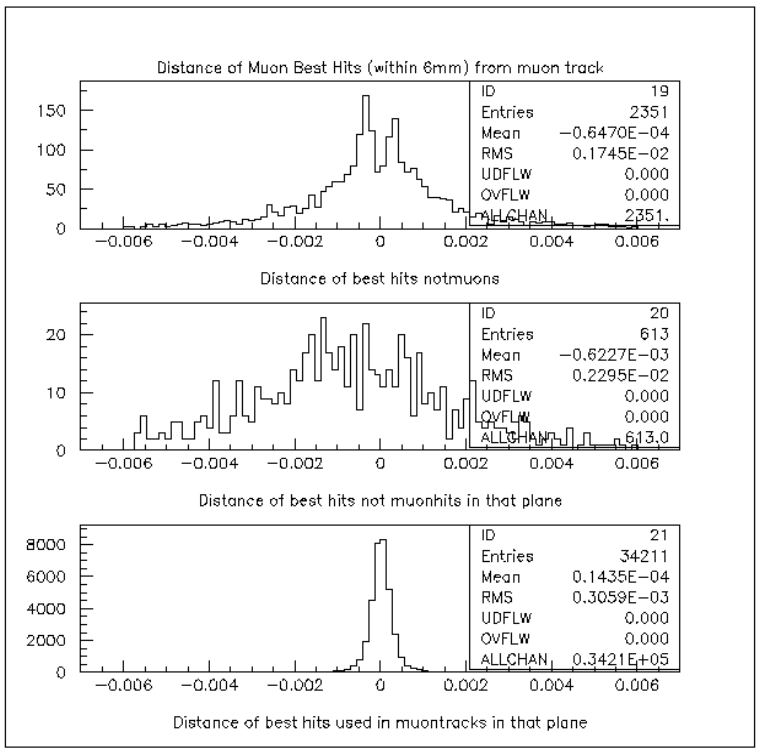
SF1 t1t3 event study - Distance of Muon hits from muon tracks



- On the top histogram we see the distance distribution of muon best hits used in muons tracks (nearly all of them are within one fiber away of the muon track).

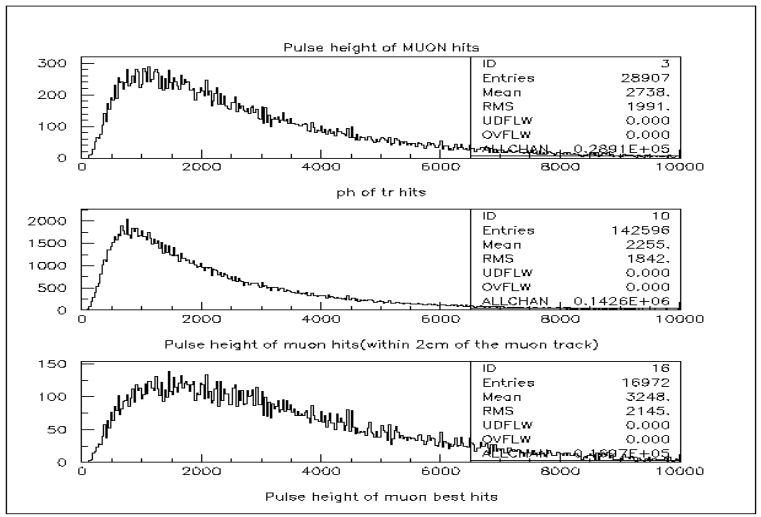
- On the bottom histogram we see the distance distribution of hits that are within 2 cm of the muon track. Again we see that the majority is within 2 fibers away of the muon tracks).

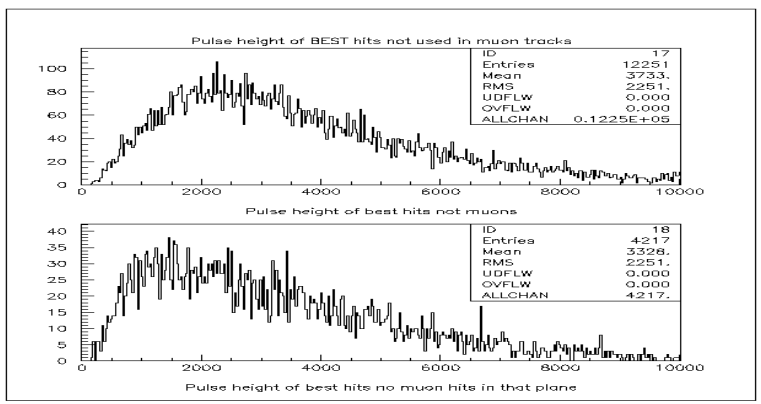
SF1 t1t3 event study - Distance of Muon best hits from muon tracks



- On the first histogram we see the distance distribution of best hits that were not used in muon tracks and most of them are 1 fiber away from the muon track.
- On the second we see the distance distribution of best hits when there were no muon hits in that plane. This distribution is asymmetric to the left.

SF2 t1t3 event study - Pulse height of muon track hits



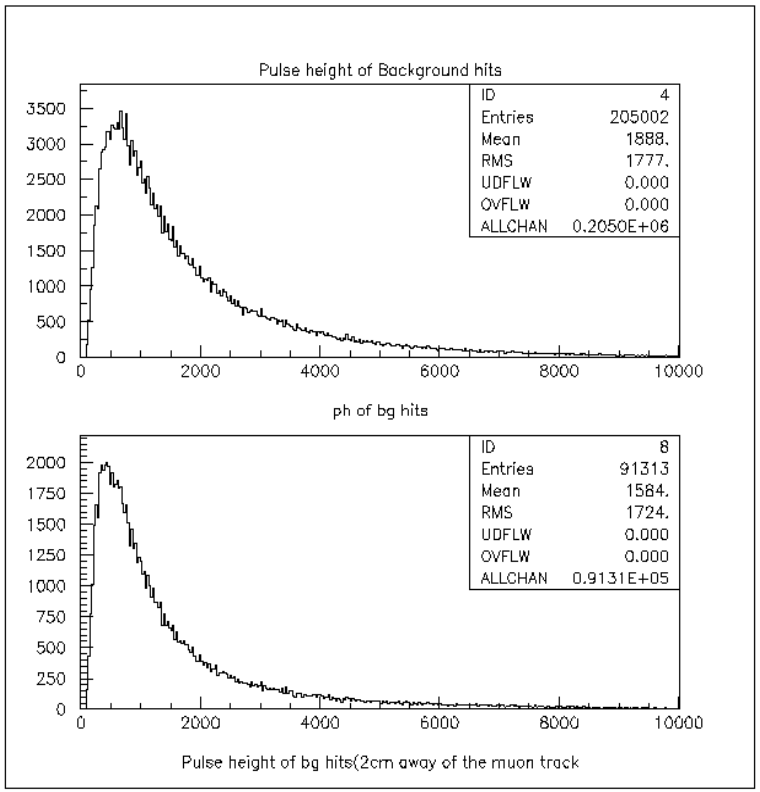


- In the first histogram we see the pulse height distribution of muon track hits (mean ~ 2738). In the second, the same distributions if we consider as muon track hits the ones within 2 cm of the muon track (mean 2255). In the third we see the same distribution but for muon track hits that were the best hits within 6 mm (mean ~3248).

- In the next 2 histograms we see the pulse height distributions of best hits (within 6mm) with muon hits in that plane (top mean ~ 3733) and when without muon hits in that plane(bottom mean 3328).

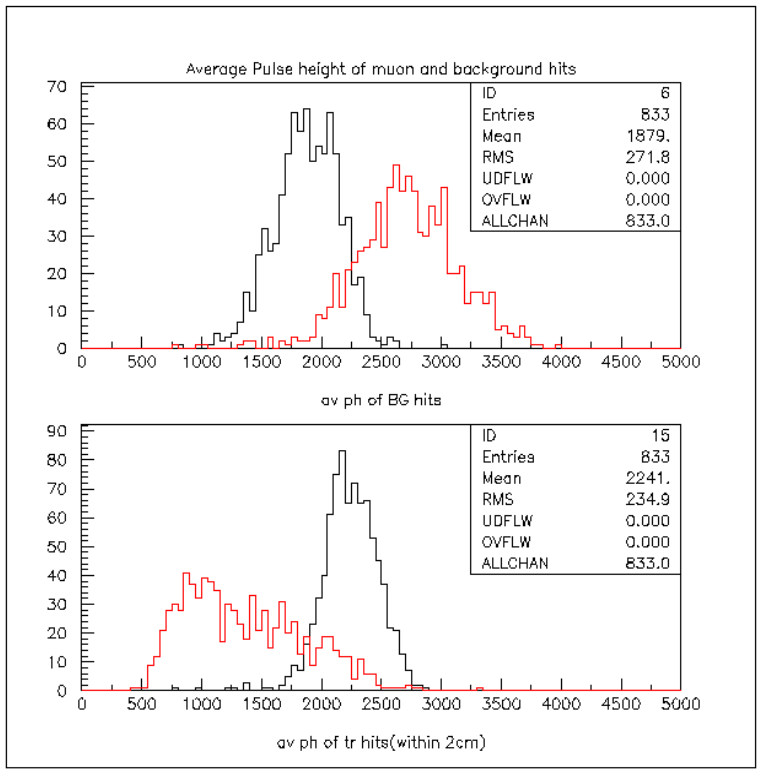
- We can conclude that a) The tracking code nearly half times misses the Best hits in a plane

SF2 t1t3 event study - Pulse height of Background hits



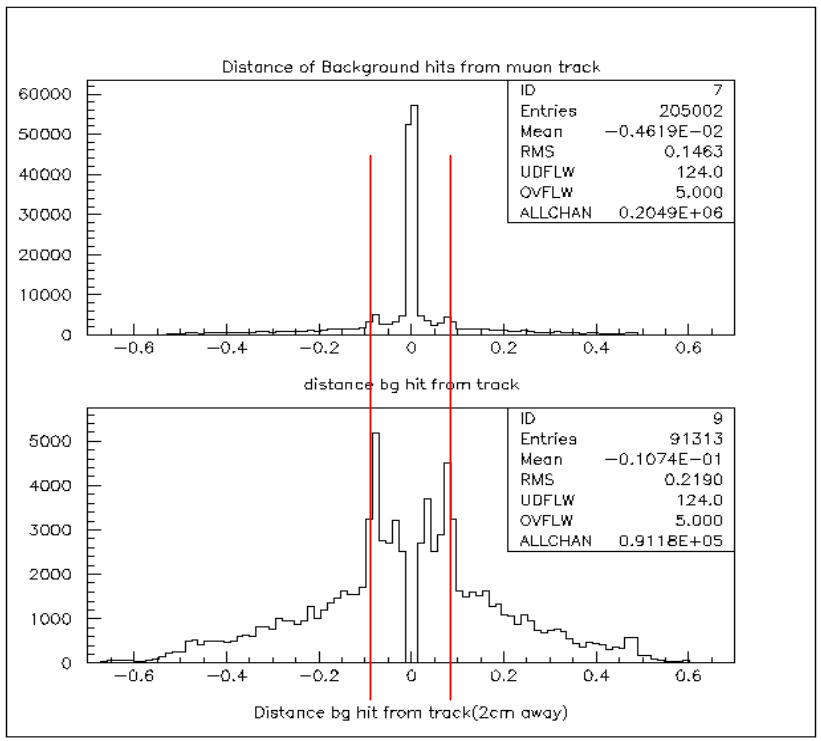
- On the top histogram we see the pulse height distribution of background hits (all the ones that do not belong to the muon track) mean ~ 1888
- On the bottom histogram we see the pulse height distribution of background hits that are 2 cm away of the muon track. Mean ~ 1584
- The slight difference is due to the fact that in the top distribution we are considering as background hits some that belong to the muon track.

SF2 t1t3 event study - Average pulse height of Background and Muon hits



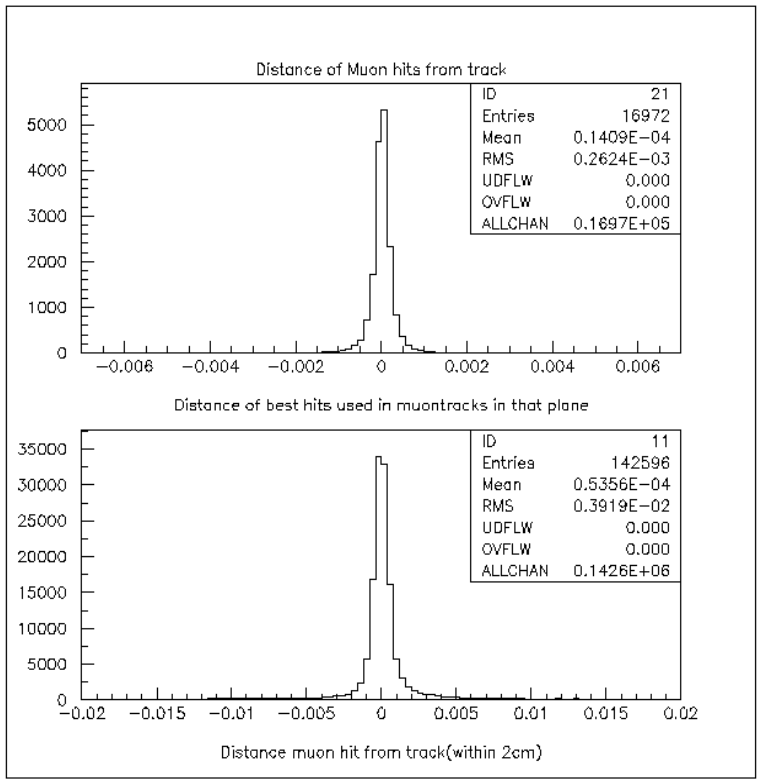
- In the top histogram we see the average pulse height distributions of muon and background hits.
- In the bottom histogram we see the average pulse height distributions of muon and background hits with the 2 cm cut.
- The mean values in the second are lowered and these two distributions show grater overlapping that the ones of SF1 decoder.

SF2 t1t3 event study - Distance of Background hits from muon tracks



- On the top histogram we see the distance distribution (in m) of background hits from the muon track (the peak on zero is due to large binsize).
- On the bottom histogram we see the distance distribution of background hits, 2 cm away of the muon track, from the muon track.
- What is unusual again is the presence of the two peaks (red line) symmetric to the center for both these 2 distributions that correspond to a distance of ~ 8 cm (<=> 40 fibers)
- The same behavior is also observed in the corresponding distributions with SF1 decoder.

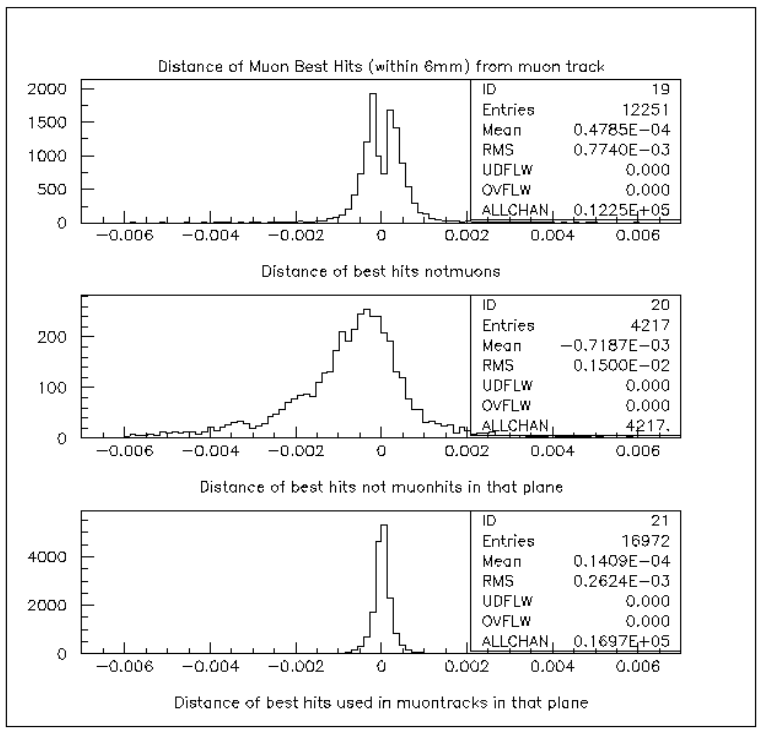
SF2 t1t3 event study - Distance of Muon hits from muon tracks



- On the top histogram we see the distance distribution of muon best hits used in muons tracks (nearly all of them are within one fiber away of the muon track).

- On the bottom histogram we see the distance distribution of hits that are within 2 cm of the muon track. Again we see that the majority is within 2 fibers away of the muon tracks).

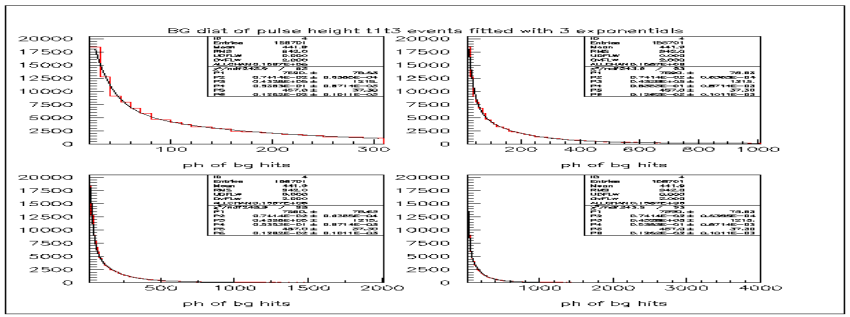
SF2 t1t3 event study - Distance of Muon best hits from muon tracks



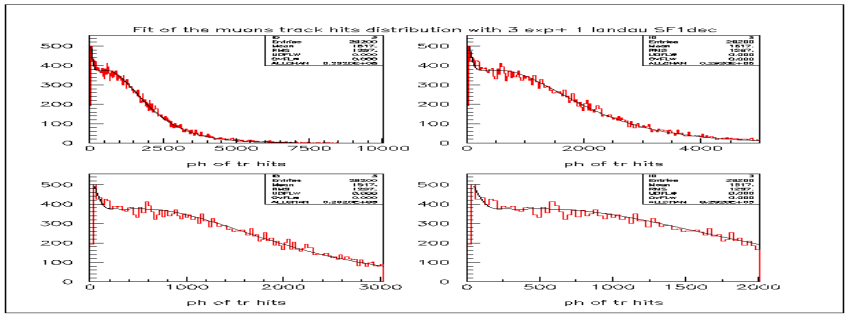
- On the first histogram we see the distance distribution of best hits that were not used in muon tracks and most of them are 1 fiber away from the muon track.
- On the second we see the distance distribution of best hits when there were no muon hits in that plane. This distribution is asymmetric to the left as was observed in SF1 decoder results also.

(attempt) Physical interpretation of Pulse height distribution in SF1 decoder

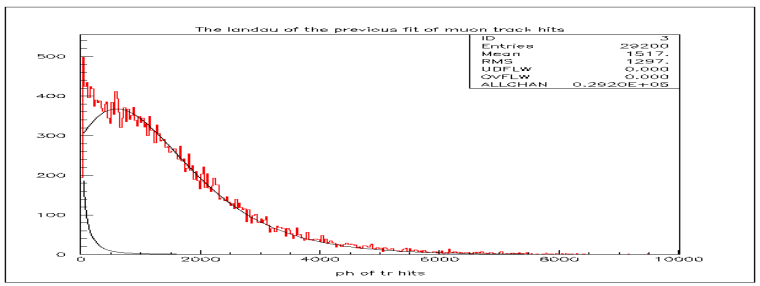
1



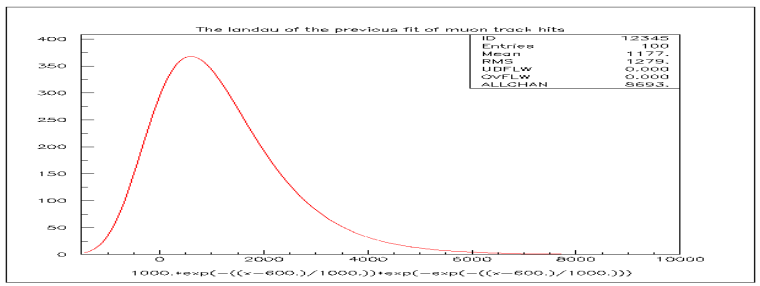
2



3



4

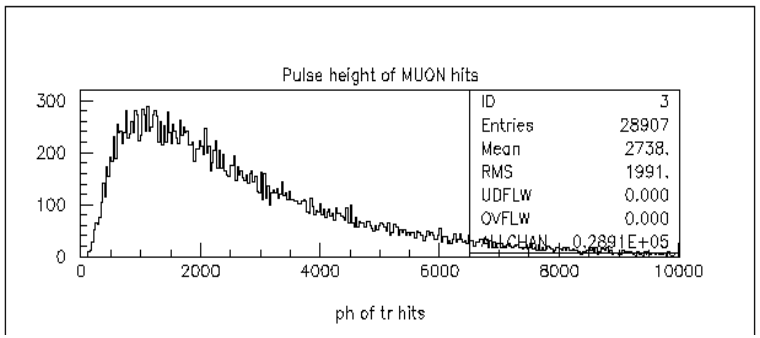


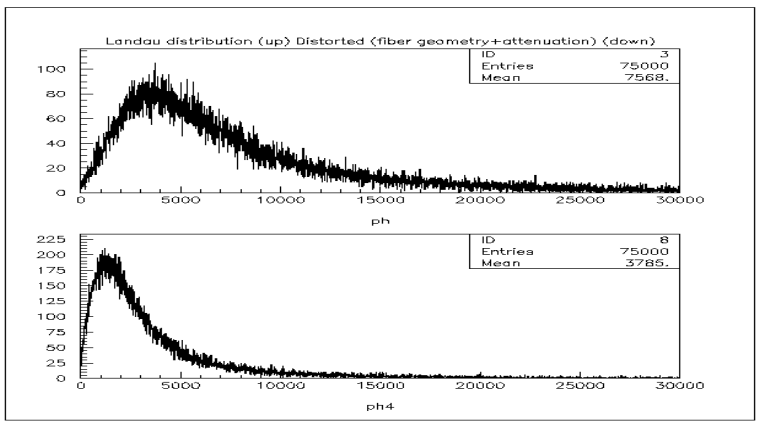
- The pulse height distribution of muon track hits was expected to be a Landau distorted due possible presence of background hits.

- In figure 1 we fitted the pulse height distribution of **background hits with the sum of 3 exponentials**. In figure 2 we fitted the pulse height distribution of muon track hits with a **Landau** + the previous 3 exponentials. In figure 3 we see the exponentials and the Landau superimposed. In figure 4 we see the resulted **Landau** from the fit.

- This Landau has no physical meaning since it has negative values also and that could be explained with possible wrong assignment of CCD pixel pulse heights in the hit.

(attempt) Physical interpretation of Pulse height distribution in SF2 decoder





- In the top histogram we see the pulse height distribution of muon track hits in SF2 decoder.
- This distribution could not be fitted with a Landau.
- In the middle histogram we see a Landau distribution and in the bottom histogram we see the same distribution distorted due to attenuation and fiber geometry. (MC)
- Could the top histogram be fitted with something like the bottom distribution (?)

Conclusion (so far)

- The two SF decoders give very different results.
- Both show an unusual behavior in distance of background hits from tracks (peaks at + - 8 cm) .
- SF decoder 2 give results that could more easily have a physical interpretation (?).
- Both of them need to be thoroughly investigated and understood.

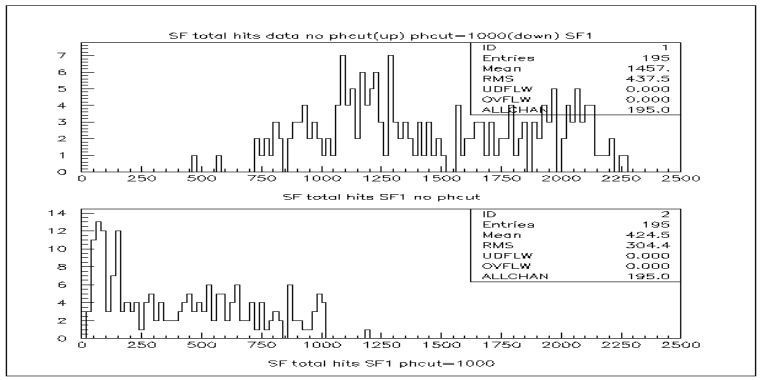
Study of Pulse height cuts (SF1 & SF2)

- We apply the following pulse height cuts in data (using SF1 decoder) and compare with MC data (using SF1 decoder) : 250 300 400 500 600 700 800 900 1000 (see next)

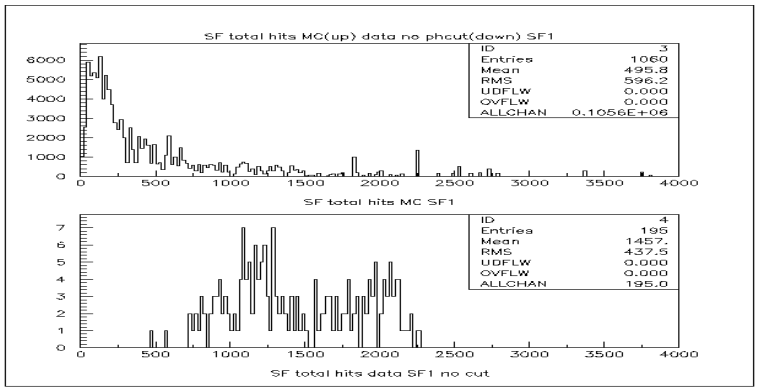
- The best results were obtained with the 1000 pulse height cut (and these are presented).

- We applied a 1200 pulse height cut in data (using SF2 decoder) and compared with MC data (using SF2 decoder).

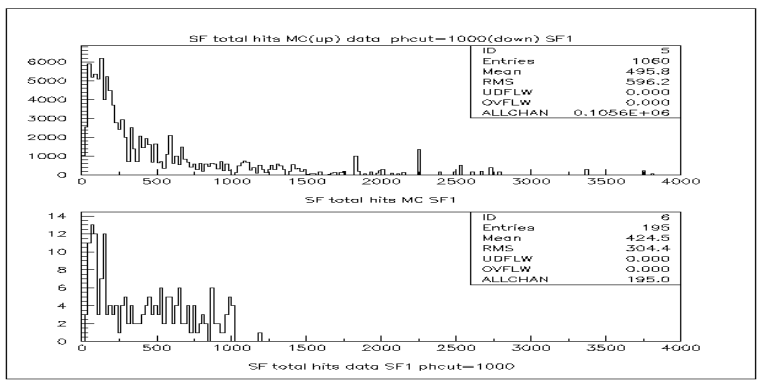
Results on Pulse height cuts (SF1)



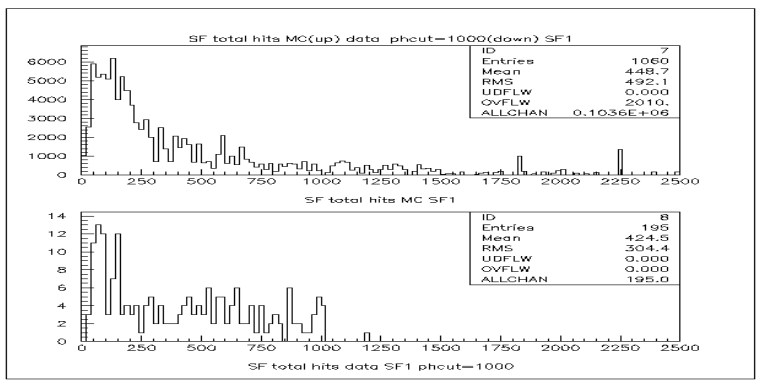
Data no cut(up) Data 1000 cut (down)



MC (up) Data no cut (down)



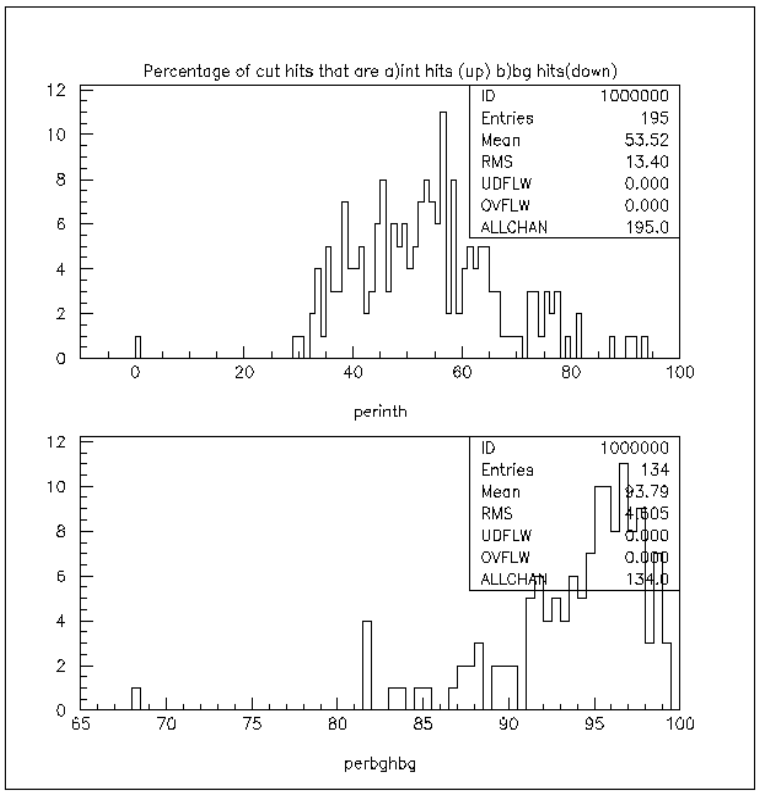
MC (up) Data 1000 cut (down)



MC (up) Data 1000 cut (down) (dif. scale

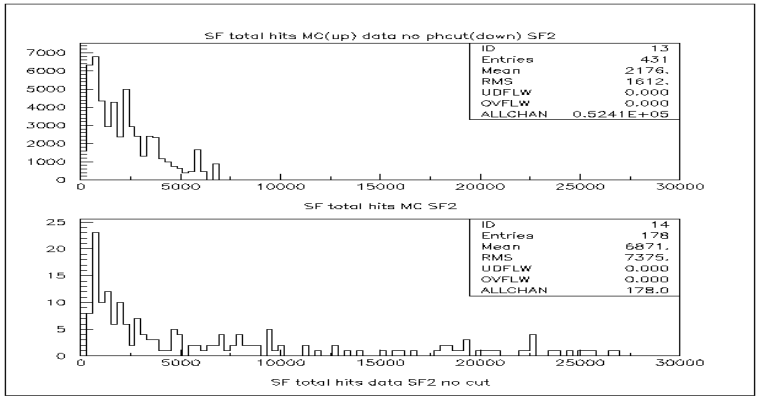
- **Results of Kolmogorov test for the bottom left (data cut -MC tail) 0.0007**
- **Results of Kolmogorov test for bottom right (data cut - No MC tail) 0.0085**

Results on Pulse height cuts cont. (SF1)

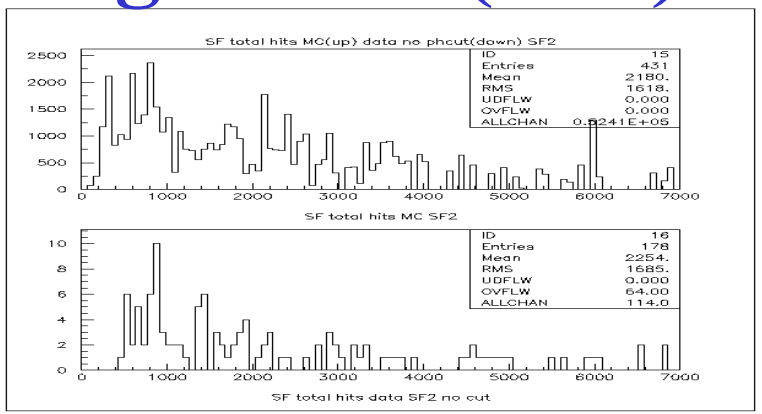


- On the top histogram we see the percentage of rejected hits (from the pulse height cut) that are “interaction” hits.
- On the bottom histogram we see the percentage of rejected hits (from the pulse height cuts) that are “background” hits.
- These results are not bad considering that many “interactions” hits could not belong to neutrino interactions in real data

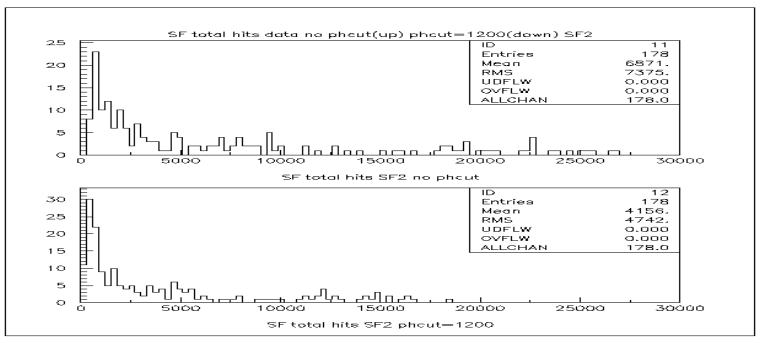
Results on Pulse height cuts (SF2)



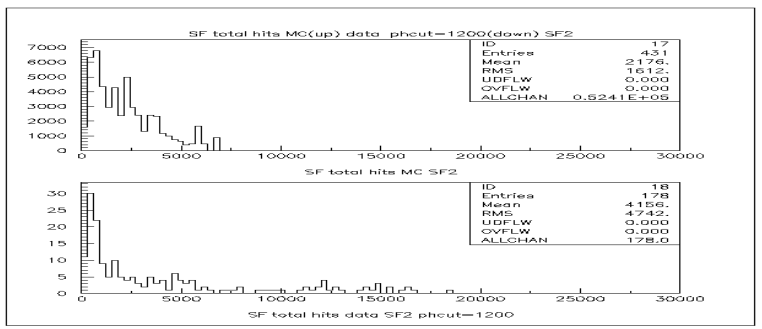
MC (up) Data no cut (down)



MC (up) Data no cut (down) dif. scale



Data no cut (up) Data 1200 cut (down)



MC (up) Data 1200 cut (down)

- **Results of Kolmogorov test for top left figure (data no cut & no tail) 0.067**
- **Results of Kolmogorov test for all the rest 0.000**
- **No results on percentages since with SF2 decoder the tracking and vertex finding fails.**

Conclusions

- The cuts in data with SF1 decoder seem effective but still the results are not quite satisfactory.
- The cut in data with SF2 decoder (at least the only one we have tried till now) shows no improvement at all.
- In SF1 decoder the problem is mainly the absence of events with large number of SF hits as in MC (Okada will try to help later because he is at a workshop now)
- In SF2 decoder the problem is mainly the presence of many events with huge number of SF hits that are not observed in MC (MC data with lower cuts not compared yet) .
- To continue we have to (and that is what we have started doing) understand both decoders in detail.